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Orbit of the Spectroscopic Binary *a* Trianguli

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ORBIT OF THE SPECTROSCOPIC BINARY α TRIANGULI.

BY W. E. HARPER, M.A.

This star ($\alpha = 1^h\ 47^m$, $\delta = +29°\ 06'$) was announced as a spectroscopic binary in *Lick Observatory Bulletin 199* from the measures of six plates, the data of which may be seen in Table II.

The star was placed on our observing list in January, 1913, and twenty spectrograms had been secured in 1913 and 1914 before an investigation of its orbit was undertaken by the writer. The spectrum is of type F5; the lines are diffuse and ill-defined and consequently the measured velocities may be considerably in error. When the twenty plates had been reduced without any greater range in velocity being found than that announced on discovery, it was felt that if the period was to be obtained, then results upon which more dependence could be placed than that furnished by a single plate would have to be secured. Consequently it was decided to make at least two plates each time the star was spectrographed and this procedure has been carried out the present autumn. The star is of photographic magnitude 4·1, and 30 minutes or less with the single-prism is sufficient to get a measurable plate.

In all eighty-five plates on Seed 27 emulsion have been secured and upon these the determination of the orbit is based. Owing to the uncertain character of the lines, the wave-lengths have not been corrected in the customary manner of equating the residuals to zero, but all the data regarding the lines are given in Table I. The residuals are given in the sense, mean minus measured. Were the corresponding corrections made, the agreement of some of the observations with the curve would be slightly improved, but on the whole no material difference in the elements would be produced.

TABLE I.

LINES USED IN α TRIANGULI.

Wave-Length.	Times Measured.	Total Weight.	Mean Numerical Residual.	Mean Algebraic Residual.	Wave-Length.	Times Measured.	Total Weight.	Mean Numerical Residual.	Mean Algebraic Residual.
4572·156	13	5	12·0	+5·4	4236·107	11	5	12·1	+6·9
4549·766	43	19	9·4	+3·3	4233·328	38	17	7·9	−2·4
4481·400	21	10	10·2	−3·8	4226·860	69	32	6·5	−1·7
4404·927	7	4	7·5	+2·4	4215·668	25	12	13·7	−11·4
4395·286	16	8	10·8	−2·0	4203·161	9	5	6·1	+0·6
4352·006	62	29	7·6	+2·6	4198·658	40	17	9·1	−0·9
4340·634	84	54	5·5	−1·3	4143·658	57	27	9·5	+1·1
4325·638	55	24	11·0	−7·0	4101·896	73	38	7·0	+3·1
4299·735	34	13	8·0	+0·2	4071·733	32	13	10·1	−1·0
4290·195	10	4	10·1	+1·7	4063·756	37	15	10·3	+6·9
4271·760	6	3	7·1	−2·4	4045·851	77	36	7·4	+2·0
4260·640	5	2	5·0	+3·4	4005·485	24	10	10·5	−5·7
4250·616	8	4	8·6	−1·6					

The first ten plates were made with the single-prism spectrograph I, whose dispersion at $H\gamma$ is 33·4 Å per millimetre; the next two with the single-prism Ia, dispersion at $H\gamma$, 54·5 Å per millimetre; and the remainder with the single-prism I′ at present in use, whose dispersion at the same region is 32·8 Å per millimetre.

The period is found from the September and October, 1915, observations to be about 1·74 days. Our 1913 and 1914 observations change this to 1·7365 days. To bring the Lick observations into the best agreement—allowance being made for the equation of light—this value was further changed to 1·73652 days which seems to be the only permissible value. As about 3600 revolutions have taken place in the interval between the dates of the first and last plates, the fifth decimal place in the period should be significant. The Lick observations are more positive than our own by about 5 km. In quite a number of stars of late, we find our own observations from 3 to 5 km. more negative than those of the Lick observatory. There is a possibility in this case

that the difference represents a real change in the velocity of the system, as our 1913 observations have likewise systematically positive residuals. The evidence, however, does not seem to be sufficient to state definitely that such is the case.

A summary of the observations will now be given. The phases are reckoned from the periastron finally determined, J. D. 2,414,552·768, using the true period 1·73652 days. A correction is applied to each for the light equation due to the velocity of the system. That due to the earth's orbit is negligible. In assigning weights to the plates not only was the number of lines measured and their weights taken into account, but the instrument employed and other conditions as well. The residuals are scaled from the curve and are approximately correct to 0·1 km. While the first decimal place in the velocities has been retained throughout, it would have been sufficient to have rounded them off to the nearest km. as greater dependence cannot be placed upon them.

TABLE II.

LICK OBSERVATIONS OF α TRIANGULI.

Date.	Julian Date.	Phase.	Velocities		Mean.	Systematic Difference −5 km.	O−C.
1898							
Sept. 19	2,414,552·791	1·449	−10·0	− 6·4	− 8·2	−13·2	−2·7
1903							
Oct. 19	6,407·954	·401	−29·6	−17·8	−23·7	−28·7	−6·4
Oct. 25	6,413·914	1·151	+ 6·6	+ 0·3	+ 3·4	− 1·6	0·0
1904							
Sept. 12	6,736·996	1·254	+ 1·0	+ 6·1	+ 4·3	− 0·7	+1·4
1906							
July 30	7,422·996	1·358	+ 5·0	+ 0·7	+ 2·8	− 2·2	+1·8
1910							
Nov. 14	8,990·718	1·068	.....	+ 7·2	+ 7·2	+ 2·2	+4·2

TABLE III.

OTTAWA OBSERVATIONS OF α TRIANGULI.

Plate.	Observer*	Date.	Julian Day G.M.T.	Phase.	Velocity.	Weight.	O–C.
		1913					
5317	P	Jan. 22	2,419,790·538	·387	−16·2	5	+ 5·5
5328	H	Jan. 28	2,419,796·554	1·193	+ 3·4	5	+ 5·2
5661	Y	Sept. 3	2,420,014·852	·699	− 9·3	4	+ 1·0
5674	C	Sept. 15	026·854	·546	− 4·2	3	+11·5
5695	G	Sept. 24	035·837	·847	− 4·3	3	+ 1·4
5716	C	Sept. 29	040·864	·667	− 4·9	5	+ 6·5
5745	P	Oct. 4	045·747	·338	−17·6	4	+ 5·7
5755	C	Oct. 6	047·823	·678	− 7·7	5	+ 3·3
5770	Y	Oct. 9	050·653	·034	−33·0	5	− 9·7
5778	C–P[1]	Oct. 13	054·729	·638	− 5·4	5	+ 7·1
5808	C	Dec. 8	110·572	·914	− 3·1	3	+ 1·0
5843	P[1]	Dec. 22	124·642	1·092	+ 0·3	3	+ 2·1
5861	P	Dec. 31	133·578	1·345	− 6·3	6	− 1·8
		1914					
5867	Y	Jan. 1	134·497	·529	−28·9	4	−12·6
5878	P[1]	Jan. 5	138·614	1·174	+ 2·7	5	+ 4·4
5884	P[1]	Jan. 12	145·633	1·247	+ 2·2	4	+ 4·5
5919	P[1]	Feb. 9	173·554	1·384	− 1·6	4	+ 2·5
5929	H	Feb. 12	176·514	·872	− 5·4	5	− 0·3
6340	P[1]	Sept. 4	380·911	·367	−25·2	3	− 3·0
6351	G	Sept. 9	385·783	·029	−26·9	5	− 3·6
		1915					
7150	H	Aug. 10	720·781	1·630	−15·0	5	+ 2·4
7151	H	Aug. 10	720·802	1·651	−15·2	4	+ 3·3
7166	C	Aug. 23	733·818	·776	− 2·8	3	+ 4·6
7167	C	Aug. 23	733·850	·807	−11·4	3	− 4·7
7173	Y	Aug. 26	736·784	·269	−26·7	4	− 2·0
7174	Y	Aug. 26	736·799	·284	−33·3	5	− 8·9
7190	H	Sept. 1	742·816	1·091	+ 2·9	5	+ 4·7
7191	H	Sept. 1	742·850	1·125	+ 1·2	5	+ 2·8
7196	Y	Sept. 2	743·764	·303	−27·6	4	− 3·6
7197	Y	Sept. 2	743·785	·324	−18·4	5	+ 5·0
7205	Y	Sept. 3	744·782	1·321	− 9·8	5	− 5·8
7206	Y	Sept. 3	744·802	1·341	− 2·9	6	+ 1·6
7212	Y	Sept. 4	745·789	·592	−11·8	6	+ 2·1
7213	Y	Sept. 4	745·810	·613	−13·6	3	− 0·6
7217	H	Sept. 8	749·765	1·094	−12·9	5	−11·1
7218	H	Sept. 8	749·800	1·129	− 2·3	5	− 0·8
7223	Y	Sept. 9	750·747	·340	−23·1	6	0·0
7224	Y	Sept. 9	750·767	·360	−23·0	7	− 0·7
7232	P[11]	Sept. 10	751·734	1·327	+ 3·8	4	+ 8·8
7233	P[11]	Sept. 10	751·760	1·353	+ 0·9	5	+ 5·7
7235	P	Sept. 11	752·686	·513	−35·2	4	−19·4
7236	P	Sept. 11	752·710	·567	−22·3	4	− 6·7
7245	H	Sept. 14	755·805	·189	−21·7	4	+ 4·0
7246	H	Sept. 14	755·826	·210	−21·8	5	+ 3·8
7253	C	Sept. 15	756·802	1·186	− 3·9	6	− 2·1

TAB. I.

OTTAWA OBSERVATIONS OF α TRIANGULI—*Concluded.*

Plate.	Observer*	Date.	Julian Day G.M.T.	Phase.	Velocity.	Weight.	O-C.
		1915					
7254	C	Sept. 15	2,420,756·825	1·209	−10·6	5	− 8·7
7260	C	Sept. 17	758·672	1·319	− 6·2	4	− 2·3
7261	C	Sept. 17	758·697	1·344	+ 1·5	3	+ 6·3
7265	P[II]	Sept. 17	758·917	1·564	−17·8	2	− 3·9
7273	Y	Sept. 21	762·596	·034	−23·2	4	+ 0·4
7274	Y	Sept. 21	762·616	·054	−33·6	2	− 9·4
7278	H	Sept. 21	762·800	·238	−21·5	4	+ 3·8
7283	H	Sept. 22	763·586	1·024	+ 1·1	3	+ 3·3
7284	H	Sept. 22	763·608	1·046	− 5·5	4	− 3·4
7294	Y	Sept. 28	769·633	·126	−28·7	4	− 2·9
7295	Y	Sept. 28	769·657	·150	−22·7	4	+ 3·1
7304	C	Sept. 29	770·792	1·284	− 3·2	5	− 0·2
7305	C	Sept. 29	770·812	1·304	− 3·6	4	− 0·1
7311	H	Sept. 30	771·659	·415	−22·7	4	− 2·3
7312	H	Sept. 30	771·683	·439	−16·0	4	+ 3·5
7319	Y	Oct. 3	774·615	1·634	−12·6	3	+ 5·0
7320	Y	Oct. 3	774·635	1·654	−12·4	3	+ 6·2
7348	H	Oct. 16	787·535	·660	−15·8	4	− 4·6
7349	H	Oct. 16	787·673	·800	−10·3	4	− 3·5
7350	H	Oct. 16	787·695	·820	− 6·7	4	− 0·5
7353	C	Oct. 20	791·750	1·402	−11·8	2	− 5·4
7354	C	Oct. 20	791·771	1·423	− 9·8	2	− 2·3
7357	Y	Oct. 21	792·600	·516	−14·2	2	+ 2·4
7358	Y	Oct. 21	792·622	·538	−17·3	3	− 4·4
7362	Y	Oct. 24	795·784	·227	−20·4	3	+ 5·0
7365	Y	Oct. 26	797·554	·261	−21·6	4	+ 3·2
7366	Y	Oct. 26	797·577	·284	−20·6	3	+ 4·0
7368	H	Oct. 28	799·656	·626	−17·3	5	− 4·8
7369	H	Oct. 28	799·695	·665	−11·6	5	− 0·4
7377	C	Nov. 5	807·628	1·651	−22·0	1	− 3·3
7380	H	Nov. 6	808·656	·943	+ 0·6	3	+ 3·9
7386	H	Nov. 7	809·451	·002	−23·1	3	− 0·6
7387	H	Nov. 7	809·480	·031	−28·3	5	− 4·8
7388	H	Nov. 7	809·509	·060	−20·8	4	+ 3·7
7392	H	Nov. 10	812·556	1·370	−12·0	3	− 6·5
7393	H	Nov. 12	814·431	1·508	−16·4	6	− 5·2
7394	H	Nov. 12	814·452	1·529	−11·8	6	+ 0·5
7398	C	Nov. 12	814·646	1·723	−22·8	6	− 0·8
7399	C	Nov. 12	814·668	·009	−14·3	4	+ 8·5
7400	C	Nov. 12	814·697	·038	−20·5	4	+ 3·2

* C = Cannon; G = Gibson; H = Harper; P = Plaskett; P[I] = Parker; P[II] = H. H. Plaskett; Y = Young.

The detailed measures of the plates are now given.

MEASURES OF α TRIANGULI.

λ	5317		5328		5661		5674		5695		5716		5745	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4572·156									−10·8	½				
4549·766	+16·0	½	+28·0	½					−33·3	½	−29·7	½		
4481·400	+35·3	¾	+27·8	¾					−21·6	½	− 1·0	½		
4352·006			+30·1	½	−26·2	½	−14·4	½			−28·4	½	−53·6	¼
4340·634	+10·2	1	+33·5	1	−26·7	1	− 26·6	½	− 2·8	½	−15·2	¼	−24·0	¾
4325·638	+ 5·1	½	+19·6	½	− 8·0	½	−18·3	½	− 8·4	½	−26·2	¼	−23·3	½
4299·735	+11·6	½												
4271·760	+22·4	½	+43·3	½	−34·2	¾			−22·6	½	−26·5	½		
4233·328			+50·5	½							− 7·0	½	−31·0	½
4226·860	+ 4·2	¾	+39·0	½	−30·8	½					− 4·2	½	−30·2	½
4198·658	+17·5	1	+30·2	¾	−47·6	½			−27·3	½	− 6·7	¼		
4143·658	+14·9	½	+18·9	½	−44·6	½	−15·7	½			−22·5	½		
4101·890	+ 1·1	¾	+40·4	1	−40·0	½					−18·2	½	−27·4	¾
4071·733											−22·4	½	−23·8	½
4063·756													−39·2	¼
4045·851	+ 6·9	¾	+26·1	½	−27·7	½	−29·8	½	−27·7	½	−23·1	½	−21·0	½
4005·485							−31·7	½					−33·4	½
Weighted mean	+ 13·05		+ 32·73		− 31·75		− 22·97		− 19·31		− 17·89		− 28·58	
V_a	− 28·89		− 28·90		+ 22·75		+ 18·92		+ 15·50		+ 13·42		+ 11·27	
V_d	− ·13		− ·18		− ·02		+ ·09		− ·18		− ·16		± ·00	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 16·2		+ 3·4		− 9·3		− 4·2		− 4·3		− 4·9		− 17·6	

MEASURES OF α TRIANGULI—*Continued.*

λ	5755		5770		5778		5808		5843		5861		5867	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4572·156											− 7·0	½		
4549·766			−46·6	½	− 8·5	½					+ 3·2	½		
4481·400	−22·8	½	−41·7	½	−15·6	¾					+30·2	½		
4404·927			−47·3	1							+13·6	¾	+15·3	½
4395·286											+16·5	½	−19·2	½
4352·006			−46·6	¾	−11·6	½	− 4·2	½	+19·0	¾	+24·8	½	− 7·4	½
4340·634	−14·0	1	−47·1	1	+ 2·6	¾	+10·8	¾	+ 6·7	¾	+20·0	¾	−11·6	¾
4325·638	−13·7	½	−54·1	¾	−20·9	½					+16·6	½	+15·8	½
4299·735	−23·0	½									+36·8	½		
4271·760			−31·0	½			+ 8·6	½			+24·6	½	−19·7	½
4260·640							+ 7·2	½						
4233·328	−11·3	½	−32·6	½										
4226·860											+18·5	¾	± 0·0	½
4198·658			−31·7	½	−24·1	½					+37·7	½		
4143·658	−23·5	½	−30·9	¾			+40·0	½	+43·7	¾	+18·9	½	+15·3	½
4101·890	−16·1	½			−13·0	½	+26·3	¾	+16·4	¾	+29·1	½	+18·4	½
4071·733					− 7·6	½								
4063·756	−13·1	½					+ 0·6	½	+ 1·2	½				
4045·851	−15·3	½	−55·0	½	−27·2	½	+24·5	¾	+16·6	¾	+23·2	½	−18·1	¾
4005·485	−27·8	½	−24·1	½	− 1·9	½	+25·9	½	+43·9	¾				
Weighted mean	− 17·69		− 41·82		− 12·25		+ 16·23		+ 24·54		+ 20·14		− 2·37	
V_a	+ 10·35		+ 8·97		+ 7·12		− 19·04		− 23·80		− 26·09		− 26·26	
V_d	− ·12		+ ·12		− ·01		± ·00		− ·17		− ·11		+ ·02	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	− 7·7		− 33·0		− 5·4		− 3·1		+ 0·3		− 6·3		− 28·9	

MEASURES OF α TRIANGULI—*Continued.*

λ	5878		5884		5919		5929		6340		6351		7150	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549·766	-31·9	¼	+53·6	½	+34·1	½	+17·1	½			-65·6	¼		
4481·300	+54·6	½	+43·8	½			+35·8	½			-72·8	¼		
4404·927			+28·0	¼			+44·4	½						
4395·286			+24·4	½					-33·0	½	-36·1	¾	-57·2	½
4352·000	+ 7·6	½	+34·6	½							-58·3	¾	-50·2	½
4340·634	+29·3	¼	+36·2	½	+22·1	¾	+35·2	¼	43·6	½	-26·9	¼	-36·1	½
4325·078							+42·9	½	42·5	½			-52·7	½
4299·735							+10·1	½	-42·7	½	-36·6	¼		
4271·760	+18·1	½	+17·1	½	+28·5	¼	+30·2	½			-53·5	¾	-44·6	½
4236·107	+36·1	½			+46·1	½							-37·0	1
4233·328	+28·1	½			+23·1	½							-41·9	½
4226·860	+31·2	½	+13·5	½	+30·1	½	+20·7	¼	-62·6	½	-39·9	½		
4198·658					+34·6	½	+25·9	½						
4143·658	+44·9	½					+19·9	½			-54·2	½	-39·6	½
4101·890	+29·1	½			+27·4	½	+22·5	½	-59·8	½	47·6	½	-41·2	½
4057·733									-52·8	½				
4063·756	+18·6	½					+18·0	½			-38·2	¾		
4045·851	+31·9	¼	+31·7	½	+28·1	½	+24·8	¼	-41·6	½	-51·1	½	-41·4	½
4005·485													-28·9	½
Weighted mean	+ 30·30		+ 31·24		+ 26·91		+ 22·68		47·31		- 47·70		- 42·30	
V_r	27·10		- 28·57		- 27·99		- 27·57		+ 22·52		+ 21·06		+ 27·45	
V_a	- ·18		- ·20		- ·19		- ·18		- ·14		+ ·06		+ ·18	
Corr.	- ·28		- ·28		- ·28		- ·28		- ·28		- ·28		- ·28	
Radial Velocity	+ 2·7		+ 2·2		- 1·6		- 5·4		- 25·2		26·9		- 15·0	

MEASURES OF α TRIANGULI—*Continued.*

λ	7151		7166		7167		7173		7174		7190		7191	
	Vel	Wt	Vel	Wt	Vel	Wt	Vel	Wt	Vel	Wt	Vel	Wt	Vel	Wt
4572·156			−29·5	½	−38·0	½								
4549·766	−46·8	½	25·5	½	−48·8	½								
4481·400									−68·4	¼			−33·4	½
4395·286			49·0	½					−69·0	¼				
4352·006	−44·6	½	45·8	½	−43·7	½	−44·3	½	−65·9	¼	−20·1	½		
4340·634	−39·2	½	25·9	½	−39·6	½	−52·0	¼	−53·7	½	−30·4	½	−20·2	½
4325·638							−39·7	½	−34·7	¼	− 4·6	½		
4299·735					−35·8	½	−55·8	¼					−25·3	¼
4271·760	−49·1	½	−40·1	½	−50·0	½							−34·0	½
4233·328	−49·7	½							−60·6	½			−1·7	½
4226·860	−53·0	½			−37·0	½	−50·2	½	−70·6	½	−12·5	½	−24·2	¼
4215·668	−44·5	½	−42·0	½					−67·4	½	−22·1	½		
4198·658	−29·4	½							−59·1	½	−30·8	¼	− 3·4	½
4143·658							−44·9	½	−63·2	½	−18·3	½		
4101·890	11·0	½			45·2	½	66·0	½			− 9·6	½	−30·0	½
4071·733							−47·5	½	59·5	½	−24·4	½	−24·8	½
4063·756											−24·0	½	−15·9	¼
4045·851	−27·6	½	−27·4	½	−33·1	½	60·5	½	−52·2	½	−31·2	¼	−33·1	¼
4005·485							−55·2	½	−56·9	½			−19·0	½
											−13·8	½	−29·9	½
Weighted mean	−42·49		−28·11		−36·00		−51·40		−58·07		−20·23		−21·96	
V_a	−27·45		+25·54		+25·51		+24·89		+24·89		+23·40		+23·40	
V_d	+ ·17		+ ·07		+ ·02		+ ·12		+ ·11		+ ·04		± 0·00	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	−15·2		− 2·8		−11·4		−26·7		−33·3		+ 2·9		+ 1·2	

MEASURES OF α TRIANGULI—*Continued.*

λ	7196		7197		7205		7206		7212		7213		7217	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4572·156	27·8	¼	−23·0	½	33·1	½	−60·2	¼			51·8	¼		
4549·766	37·9	½	−46·5	½	41·5	½	38·2	½	−29·3	½	49·1	¼		
4395·280			40·0	½									21·2	½
4352·006			37·1	½	47·7	½	35·3	½	37·8	½	46·3	¼	−45·0	¼
4340·634	53·0	¾	−40·1	¼	50·9	½	22·6	½	43·2	¼	46·2	¼	49·1	¼
4325·658					25·3	½	−21·4	¼	31·0	½	49·9	¼		
4299·735	36·2	¼	−37·3	½	45·8	¼			52·1	¼	51·6	¼		
4271·760	26·4	½	−33·7	¼	45·9	¼	16·9	½	32·2	½	−43·6	¼		
4260·640							−21·0	½	40·0	½				
4236·107	45·6	½											−40·8	½
4233·328					40·7	¼							−21·1	½
4226·860	39·4	½	−30·3	¼	38·3	½	16·2	½	42·0	½	−22·2	¼	− 4·3	½
4215·668							6·0	½	31·4	½			−18·0	½
4198·658									20·9	¼			28·8	¼
4143·658			54·5	½	26·2	½	29·4	½	34·3	½	−29·6	¼	32·5	¼
4101·880	72·9	¾	−46·9	¼	31·7	½	32·4	½	31·3	¼	47·1	¼	54·6	½
4071·743			24·0	¼			6·7	½	29·4	½				
4063·756	68·5	½	53·2	½	33·6	¼	38·0	½						
4045·854	67·5	½			21·2	¼	42·2	½	96·7	¼	−38·3	¼	51·3	½
4005·485					17·0	¼	22·6	½						
Weighted mean	− 50·56		41·41		− 35·51		− 25·56		− 34·26		− 35·97		− 34·09	
V_r	+ 23·15		+ 23·15		+ 22·90		+ 22·90		+ 22·65		+ 22·05		+ 21·44	
V_l	+ 11		+ 09		+ 10		+ 05		+ 07		+ 04		+ 10	
Corr.	− 28		− 28		− 28		− 28		− 28		− 28		− 28	
Radial Velocity	− 27·6		18·4		9·8		− 2·9		− 11·8		13·6		− 12·9	

MEASURES OF α TRIANGULI—*Continued*

λ	7218		7223		7224		7232		7233		7235		7236	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549·766			−63·0	¾					−29·2	½				
4534·139									−10·4	½				
4501·448									−11·7	½				
4395·286	+12·5	¾					12·4	¼	7·7	½	−52·0	¼		
4352·006			−14·6	¾	15·4	1	29·7	1	−37·9	½	−68·5	½	−49·5	¼
4340·634	−22·1	¾	−43·6	½	−48·8	¾	28·1	½	17·2	¼	−48·4	1	27·2	½
4325·638	− 3·0	½							− 5·6	½	−44·7	¾		
4299·735					−31·1	½							47·8	½
4271·760	−38·9	¼	−33·5	1	−56·7	¾	+ 6·4	¼	−40·1	½	−55·0	½	−64·8	½
4250·616					−31·5	¾								
4236·107					−62·4	¾								
4233·328	−27·2	½	−43·2	¾	−41·8	¾	14·5	½	−22·3	½	−58·8	½	−19·3	¼
4226·860	−21·6	¼	−48·9	½	−37·7	¾	− 9·7	½	20·9	½	−43·0	½	−55·9	¼
4215·668			−39·1	¾	14·2	¾	+ 1·0	½						
4198·678			−32·5	½	59·0	½							53·0	¼
4143·658			−48·0	½	−43·8	¾	22·7	¼			−73·6	½	−36·4	½
4101·890	36·4	½	42·3	¼	42·9	¾	21·9	½	26·1	¼	−53·2	½	40·4	¼
4071·733	45·2	½	−28·3	½					−14·8	½	−65·6	½		
4063·756	−46·9	½	−55·3	½	64·2	½								
4045·851	21·8	½	−41·4	½	48·2	½	25·8	¼	29·2	½	−62·1	¼	37·1	½
4005·485	18·2	½									44·8	¼	42·5	¼
Weighted mean	23·52		44·04		43·97		− 16·82		− 19·76		− 55·62		− 42·71	
V_0	+ 21·44		+ 21·44		+ 21·44		+ 20·81		+ 20·84		+ 20·51		+ 20·51	
V_d	+ 04		+ 12		+ 10		− 14		+ 10		+ 19		+ 16	
Corv	− 28		− 28		− 28		− 28		− 28		− 28		− 28	
Radial Velocity	− 2·3		− 23·1		− 23·0		+ 3·8		+ 0·9		− 35·2		− 22·3	

MEASURES OF α TRIANGULI—*Continued.*

λ	7245		7246		7253		7254		7260		7261		7265	
	Vel	Wt	Vel	Wt	Vel	Wt	Vel	Wt	Vel	Wt	Vel	Wt	Vel	Wt
4572·156					−25·8	½							39·0	½
4549·766	−29·7	½			15·2	½							−29·3	¼
4395·286			−45·2	½	20·2	½	−25·5	½	−25·5	½				
4352·006	−51·2	½	−44·6	½	15·4	½	28·5	½	−23·9	¼				
4340·634	−33·1	½	−43·8	1	22·8	1	−28·8	1	−20·5	1	−11·9	¼	37·2	¼
4325·638	−29·4	½	−30·3	½	9·0	1	−32·2	¼			+ 0·0	¼		
4299·735			−28·0	½	11·0	¼							−43·4	½
4271·760	−35·6	½			−41·4	¼	−30·7	½	−34·8	½	−23·2	¼		
4250·616			−55·4	½										
4236·107			−59·9	¼	−31·9	¼								
4233·328							−38·0	½	−45·4	½				
4226·860	−37·7	½	−48·2	½	18·2	½	−14·7	½	−22·4	¼	−23·3	½	−21·6	½
4198·658			−28·5	1	−24·7	¼	−29·0	½	−16·2	½				
4143·658			−35·3	½					−25·9	½	−35·6	¼		
4101·800	47·6	½	−49·0	¼	−32·9	½	10·2	½	−20·8	½	−29·0	¼	−36·1	½
4071·733	−50·5	½			−3·2	½			4·1	¼				
4063·756							−29·0	¼	−13·4	¼	− 5·3	¼		
4045·851	−53·4	½	−39·2	1	−31·2	½	−26·5	½	33·0	¼	−10·0	¼	−40·3	½
Weighted mean	− 40·87		− 40·90		− 22·75		− 29·39		− 24·55		− 16·84		− 35·80	
V_4	+ 19·45		+ 19·45		+ 19·10		+ 19·10		+ 18·44		+ 18·44		+ 18·44	
V_3	+ ·00		− ·04		+ ·00		− ·01		+ ·19		+ ·15		− ·18	
Curv.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		+ ·28	
Radial Velocity	− 21·7		− 21·8		− 3·9		− 10·6		− 6·2		+ 1·5		− 17·8	

MEASURES OF α TRIANGULI—*Continued*

λ	7273		7274		7278		7283		7284		7294		7295	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549·766	−19·5	¼									−36·1	½	−27·9	¼
4352·006			−56·1	½			−11·4	¾	−19·5	½				
4340·634	−44·7	¾	−46·0	¾	−37·4	¼	−19·0	½	−28·3	¼	−36·9	¼	−31·5	½
4325·638	−29·4	½	−25·7	¼			−29·3	½	−20·2	½			−47·5	¼
4271·760	−38·2	¾	−66·8	¾					14·6	½	−62·6	½	45·2	¾
4233·328	−28·7	¼					− 9·1	½			−56·7	½		
4226·860	−43·7	½	−35·5	¾	−27·0	¼	−13·6	½			−29·5	½	−36·7	½
4215·668	−24·6	½									−31·2	½		
4198·658					−35·5	½	− 7·4	¾	28·4	½	−41·4	½	−23·4	½
4143·658	−52·2	¼			−44·1	½			−32·7	½	−31·1	¼	−39·2	½
4101·890	−55·2	¼			−34·4	½	−24·6	½	− 6·8	½	−43·3	¼	−40·6	¼
4071·733									−32·6	¼	−40·2	½	−33·9	¼
4063·756					−49·4	¼			−15·2	½	−63·6	¼	−40·6	¼
4045·851	−47·9	¼	−74·4	¼	−40·6	¼			−26·9	¼	−54·7	½	−33·6	½
4005·485					−39·4	½								
Weighted mean	− 40 16		− 50 52		− 38 44		− 15 45		− 22 06		− 42 75		− 36 76	
V_0	+ 16·98		+ 16 98		+ 17 08		+ 16·58		+ 16·58		+ 14 13		+ 14 13	
V_d	+ ·25		+ ·23		+ ·12		+ ·26		+ ·24		+ ·20		+ ·18	
Curv.	− ·28		− ·28		− ·28		− ·28		·28		·28		·28	
Radial Velocity	− 23·2		− 33·6		− 21·5		+ 1·1		− 5·5		− 28·7		− 22·7	

MEASURES OF α TRIANGULI—*Continued*

λ	7304		7305		7311		7312		7319		7320		7348	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549·766	−28 7	1	−20 1	1					−35 8	1				
4481 400									−31 1	1				
4395 286			30 9	1										
4352 006	13 8	1	23 1	1					−37 2	1	−21 0	1		
4340 634	−21 2	1	9 7	1	41 9	1	22 2	1	−20 5	1	−23 6	1	24 4	1
4325 658	18 9	1							−4 6	1	13 6	1	−2 5	1
4299 595													12 5	1
4271 760	14 5	1			24 8	1			−38 6	1	16 8	1		
4260 640	−18 9	1												
4250 616									−25 7	1				
4233 328	−9 2	1					−26 7	1	−28 0	1			−18·6	1
4226 860	−15 3	1	−31 9	1	−22 3	1	−23 7	1	−21 0	1	−27 4	1		
4215 668	13 9	1					−25 8	1					−0·6	1
4198 658	5 0	1	16·0	1							−42 0	1	−41·8	1
4143 658			10 4	1	45 8	1	−30 9	1			−35 3	1	−19 8	1
4101 800	29 8	1	20 9	1	43 4	1	36 4	1			20 2	1	14 2	1
4071 733	−7 7	1	−2 3	1	9·0	1	−39 9	1					13 1	1
4063 756	−20 7	1			60 1	1	30 1	1	14 0	1	31 0	1	29 5	1
4045 851	20 6	1	17 9	1	34 8	1	20 2	1			24 5	1	16 6	1
4005 185													−38 8	1
Weighted mean	16 57		−16 93		−35 92		29 20		24 58		−24 28		24 78	
V_0	−13 72		+13 72		+13 31		+13 31		+12 00		+12 00		+6 00	
V_1	05		07		−16		−12		+21		+18		+24	
Curv	−28		28		−28		28		28		−28		28	
Radial Velocity	3 2		−3 6		22 7		16·0		−12 6		−12 4		−15 8	

MEASURES OF α TRIANGULI *Continued*

λ	7349		7350		7353		7354		7357		7358		7362	
	Vel	Wt	Vel.	Wt	Vel	Wt	Vel.	Wt	Vel.	Wt	Vel.	Wt	Vel.	Wt.
4352·006			-11·3	½	1·2	¼	-18·1	¼	-31·0	¼	-34·0	½	-19·8	¼
4340·634	- 2·8	¼	+ 3·5	½	-12·6	½	-15·5	¼	- 16·8	¼	- 11·0	½	-26·3	½
4325·638	12·8	¼	18·0	½							+ 4·1	½	- 17·6	½
4299·735	- 1·6	½	-30·5	¼							-22·5	½	-33·9	¼
4290·195	-35·3	¼			- 6·2	½					-27·0	¼		
4271·760	- 5·5	¼			-27·8	¼			23·4	¼				
4236·107					+ 3·8	¼								
4233·328					- 10·2	¼	-36·4	¼	- 5·8	¼				
4226·860	21·4	¼	8·2	½	23·2	¼							20·4	½
4215·668			+ 6·2	½	25·2	¼					26·5	¼		
4198·658	- 9·0	¼	12·4	½			17·5	¼						
4143·658	-40·2	¼	+ 8·0	½	24·1	¼	22·5	¼			-28·2	¼	- 18·5	¼
4101·890	-24·0	½	33·6	½	16·5	½	-29·0	¼	-31·7	½	-30·3	¼	-15·4	¼
4071·733	23·4	¼					-28·5	¼						
4063·756			-21·4	¼	-34·8	½	-51·5	¼						
4045·851	24·0	¼	17·6	½	8·6	½	-30·0	¼	-19·0	¼	- 27·8	½	-25·3	½
4005·485	- 25·8	¼			-17·0	¼	+ 4·2	½						
Weighted mean	- 16·05		- 12·48		- 15·66		- 13·66		- 17·68		- 20·69		- 22·10	
V_R	+ 6·00		- 6·00		+ 1·05		+ 1·05		+ 3·54		+ 3·54		+ 2·08	
V_I	+ ·07		+ ·04		+ ·07		+ ·11		+ ·15		+ ·12		+ ·13	
Curv	- ·28		- ·28		- ·28		·28		·28		- ·28		- ·28	
Radial Velocity	- 10·3		- 6·7		11·8		9·8		11·2		17·3		20·4	

MEASURES OF α TRIANGULI—*Continued*

λ	7365		7366		7368		7369		7377		7380		7386	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4572·156									−20·6	¼			−12·3	¼
4549·766					−33·1	¼			−19·6	¼			−35·7	¼
4481·400					−13·6	½			−21·6	¼				
4352·006	−30·5	½	−13·8	¼	−20·6	¼	− 6·4	¼			+21·4	½	−45·4	¼
4340·634	−22·6	¼	−20·5	½	− 4·2	½	−17·2	½			+11·8	¼	+16·7	¼
4325·638	−24·5	½			− 4·4	½	+ 9·8	¼	− 8·0	¼			+ 9·7	¼
4299·735					−27·8	¼	−14·3	¼			− 5·4	¼		
4290·195	− 8·6	½			−23·2	½	− 8·0	¼			− 6·0	¼		
4271·760			6·4	¼	−21·4	¼	+ 9·4	¼			+ 1·8	¼		
4260·640									−19·7	¼				
4250·616											+ 2·8	¼		
4236·107											−25·2	¼		
4233·328					−14·7	¼							−25·1	¼
4226·860	−12·4	¼	27·0	½			− 8·2	¼			+ 7·2	¼		
4215·668					+ 4·2	½	+ 6·3	½			+17·5	¼		
4198·658	−19·4	¼			−20·4	½	−23·0	¼			+13·6	½	−30·0	¼
4143·658	−10·9	½					−21·1	½					−16·5	¼
4101·890	−39·0	¼	−17·0	½			−21·6	½			− 3·4	½		
4071·733	−35·3	¼	−44·8	¼										
4063·756			−16·8	¼			−24·0	¼						
4045·851	− 22·5	½	−28·4	½	−27·3	¾	−22·5	½						
4005·485	− 8·0	¼	−12·8	¼	− 9·8	¼	+ 3·6	½						
Weighted mean	− 22·58		21·60		17·22		11·40		− 17·90		+ 5·68		− 17·33	
V_2	+ 1·11		− 1·11		+ ·14		− ·14		− 3·91		− 4·84		− 5·78	
V_1	+ ·20		− ·17		+ ·06		− ·02		+ ·13		+ ·00		+ ·26	
Corr.	− ·28		− ·28		− ·28		− ·28		− ·28		− ·28		− ·28	
Radial Velocity	21·6		20·6		17·3		11·6		− 22·0		+ 0·6		− 23·1	

MEASURES OF α TRIANGULI—*Continued*

λ	7387		7388		7392		7393		7394		7398		7399	
	Vel.	Wt.	Vel	Wt.	Vel.	Wt.	Vel	Wt	Vel	Wt	Vel	Wt	Vel	Wt
4572·156	−16·4	½												
4549·766	−35·7	¼			− 6·5	¼	−21·4	½	+11·4	½			−26·6	¼
4481·400					− 9·8	¼	−20 1	½	− 14 4	¼			+ 7·8	½
4404·927	−35 4	½												
4352·006	−28 4	½	−19·1	¼			−10·3	½	− 8·6	½	−26·5	½	− 0 4	½
4340·634	−18 2	¼	− 7 9	½	+ 1·0	¼	− 9·2	¼	− 1 9	¾	−20·5	¼	− 3 0	½
4325·638			− 2·8	¼	+ 4·8	¼	+ 6·0	¼	+ 8·0	½	−15 7	½	+11 8	½
4299·735	− 6·1	¼	−14·7	¼			−13·1	½			−14·9	½	−16·5	¼
4290·195	−40·3	¼									− 9 8	½	−17 8	½
4271·760	− 4·4	¼	10·8	¾	+ 4·6	½	−24·6	½	− 2 1	½	−15·4	½	−12 7	¾
4250·616	−37·4	¼			+15 1	¼			− 0·9	½	−14 0	½		
4236·107	+12·4	¼					−19·7	½			−29 0	½		
4233·328									− 2·1	½	− 0·4	½		
4226·860	29·9	½	−23 7	¾			−13·2	½	− 6·2	½	−15·9	½	− 8·7	¼
4215·668													− 7·1	¼
4202·161							− 4·8	¼			−12·2	½		
4198·658	− 3·0	½	−12 8	¾	−23·4	¼	−12·0	½	−11·8	½	− 7·4	½	+ 5·3	¼
4143·658			−24·3	½	−37·4	¼	+ 8·4	½			−23·8	½	+ 0·2	¾
4101·890	−15·0	¼					− 1·6	½	−16·2	½	−18·2	½	−15·9	¼
4071·733		½	−21·1	½			+ 0·4	½	− 7·9	½				
4063·756							−11·9	½	− 7·4	½			− 7·2	¼
4045·851	−1	¼	−15·4	½	− 7·6	¼	+ 1·8	¼	− 7·0	½	− 6·6	¼	−23·8	½
Weighted mean	− 22 50		− 14·91		5 56		9·12		− 4 53		− 15 24		6 62	
V_0	− 5 78		− 5 78		6 33		− 7 24		− 7·24		− 7 30		7 30	
V_4	+ ·25		+ ·22		+ 15		+ ·26		+ ·26		+ ·00		− 05	
Curv	− ·28		− ·28		− 28		− ·28		− ·28		− ·28		28	
Radial Velocity	− 28·3		− 20·8		− 12·0		− 16·4		− 11·8		− 22 8		− 14 3	

MEASURES OF α TRIANGULA—*Concluded*

λ	7400													
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4549·766	−16·6	1												
4481·400	7·2	1												
4352·006	−12·6	1												
4340·634	0·0	1												
4299·735	−12·6	½												
4271·760	−29·2	1												
4236·107	− 9·0	½												
4233·328	− 2·4	1												
4226·860	− 1·6	1												
4215·668	+20·2	1												
4198·658	+ 5·2	1												
4143·658	−47·4	½												
4101·890	−21·4	¼												
Weighted mean	− 12·86													
V_0	− 7·30													
V_d	− ·09													
Curv	− ·28													
Radial Velocity	20·5													

The Ottawa observations were grouped according to phase into 12 normal places and preliminary elements obtained by the usual graphical method. These elements are the following:

$$P = 1{\cdot}73652 \text{ days}$$
$$e = {\cdot}10$$
$$\omega = 105°$$
$$K = 12 \text{ km.}$$
$$\text{Max.} = 1{\cdot}5 \text{ km.}$$
$$\text{Min.} = -25{\cdot}5 \text{ km.}$$
$$T = \text{J. D. } 2{,}414{,}552{\cdot}948$$
$$\gamma = -13{\cdot}19 \text{ km.}$$

NORMAL PLACES.

	Phase Preliminary.	Phase Final.	Velocity.	Weight.	O–C Preliminary.	O–C Final.
1	·975	·835	− 6·8	·5	+0·3	−0·9
2	1·207	1·067	− 2·1	·6	−0·2	−0·3
3	1·327	1·187	− 1·6	·6	0·0	+0·2
4	1·466	1·326	− 3·2	·8	+1·0	+0·8
5	1·531	1·391	− 7·8	·3	−1·3	−1·7
6	1·707	1·567	−14·6	·6	+1·6	−0·6
7	·158	·018	−24·4	·7	−1·1	−1·4
8	·279	·139	−24·0	·5	+1·4	−1·7
9	·407	·267	−25·3	·5	−0·7	−0·5
10	·523	·383	−21·8	·8	+0·5	−0·2
11	·668	·528	−17·0	·4	−0·4	−0·6
12	·798	·658	−10·3	·7	+2·7	+1·2

OBSERVATION EQUATIONS FOR α TRIANGULI.

	Weight.	x	y	z	u	v	$-n$
1	·5	1·000	+ ·282	− ·752	+ ·744	− ·688	− ·3 = 0
2	·6	1·000	+ ·707	− ·698	+ ·160	− ·232	+ ·2 = 0
3	·6	1·000	+ ·731	+ ·020	− ·237	+ ·136	·0 = 0
4	·8	1·000	+ ·521	+ ·922	− ·723	+ ·677	−1·0 = 0
5	·3	1·000	+ ·330	+1·051	− ·905	+ ·913	+1·3 = 0
6	·6	1·000	− ·487	− ·193	−1·976	+1·178	−1·6 = 0
7	·7	1·000	−1·082	−1·035	− ·665	+ ·657	+1·1 = 0
8	·5	1·000	−1·254	− ·456	− ·199	+ ·110	−1·4 = 0
9	·5	1·000	−1·191	+ ·467	+ ·266	− ·355	+ ·7 = 0
10	·8	1·000	− ·994	+ ·682	+ ·581	− ·617	− ·5 = 0
11	·4	1·000	− ·518	+ ·674	+ ·869	− ·806	+ ·4 = 0
12	·7	1·000	− ·219	+ ·162	+ ·902	− ·813	−2·7 = 0

Where $x = \delta\gamma$

$y = \delta K$

$z = K.\delta e$

$u = K.\delta\omega$

$$v = \frac{K}{(1-e^2)^{\frac{3}{2}}} \cdot \mu \cdot \delta T = [1 \cdot 64427]\delta T.$$

NORMAL EQUATIONS.

$$\begin{aligned}
7 \cdot 000x - 1 \cdot 906y + \cdot 364z - \cdot 157u + \cdot 075v - 3 \cdot 110 &= 0 \\
4 \cdot 301y + \cdot 237z - \cdot 319u + \cdot 322v + \cdot 578 &= 0 \\
3 \cdot 140z + \cdot 197u - \cdot 220v - \cdot 899 &= 0 \\
3 \cdot 189u - 3 \cdot 138v - \cdot 908 &= 0 \\
3 \cdot 127v + \cdot 714 &= 0
\end{aligned}$$

Whence $\delta\gamma = +\cdot 54$ km.

$\delta K = +\cdot 10$ km.

$\delta e = +\cdot 021$

$\delta\omega = +30^\circ \cdot 56$

$\delta T = +\cdot 1405$ day

The value of Σpvv for the normal places was reduced from 11·1 to 6·2. One solution was sufficient, as the residuals obtained by substitution in the observation equations and by computing directly from the corrected elements agreed within 0·2 km. The probable error of a plate computed from the last two columns in the table of observations, using the formula

$$r = \pm \cdot 6745 \sqrt{\frac{\Sigma pvv}{n-1} \cdot \frac{n}{\Sigma p}},$$

is ±3·5 km. per sec. No plates have been omitted, even though some of them were somewhat underexposed; one in fact having only three or four minutes exposure. If four of the largest residuals were omitted, the probable error would become ±2·9. However, the probable error of 3·5 is very satisfactory considering the character of the spectrum for measurement.

A plot of the observations is given in Fig. 1, the circles with dark centres representing the Lick observations when $-5{\cdot}0$ km. has been added to each of them. The grouped velocities are shown with the curve from the final elements in Fig. 2.

The final values of the elements, then, with their probable errors are the following.

$$
\begin{aligned}
P &= 1{\cdot}73652 \text{ days} \\
e &= {\cdot}121 \pm {\cdot}041 \\
\omega &= 135°{\cdot}56 \pm 23°{\cdot}35 \\
K &= 12{\cdot}10 \text{ km.} \pm {\cdot}46 \text{ km.} \\
\gamma &= -12{\cdot}65 \text{ km.} \pm {\cdot}36 \text{ km.} \\
A &= 11{\cdot}05 \text{ km.} \\
B &= 13{\cdot}15 \text{ km.} \\
T &= \text{J. D. } 2{,}420{,}793{\cdot}821 \pm {\cdot}105 \\
a \sin i &= 286{,}800 \text{ km.}
\end{aligned}
$$

Dominion Observatory,
Ottawa,
November, 1915.

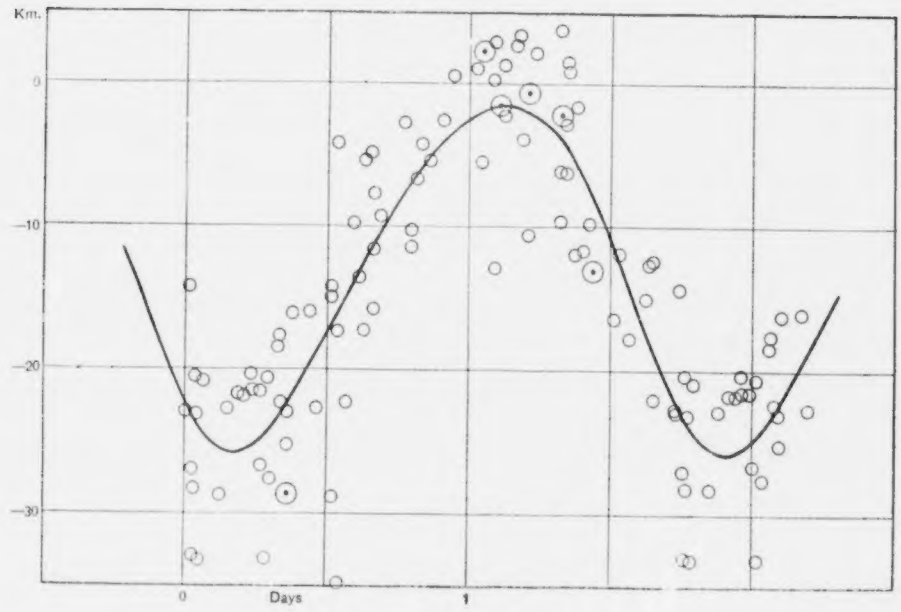

FIG. 1—Observations of α Trianguli.

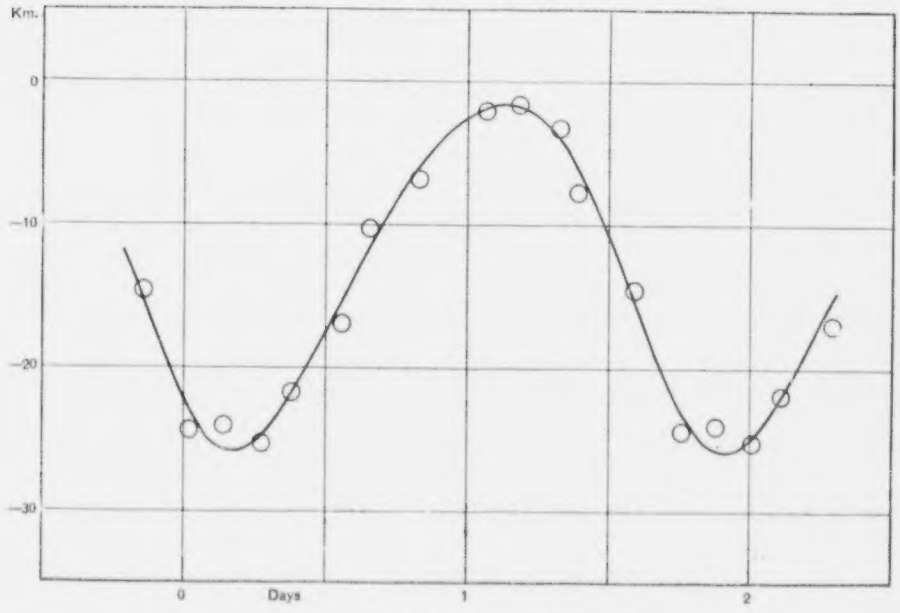

FIG. 2—Velocity Curve of α Trianguli